MONTHLY PROGRESS REPORT

PERIOD 1 JULY 1963 – 31 JULY 1963

RESEARCH AND DEVELOPMENT OF AN OPEN-CYCLE FUEL CELL SYSTEM

Contract No. NAS8-26967
Proposal Request Number TP 2-831321

NASA CR-55966; Rept. 15

no index

Prepared for

George C. Marshall
Space Flight Center
Huntsville, Alabama

OTS: PRICE
XEROX $ 1.10 ph
MICROFILM $ 0.80 mf

By

SPACE AND DEFENSE
SCIENCES DEPT.

RESEARCH DIVISION

ALLIS-CHALMERS Mfg. Co.
MILWAUKEE 4, WISCONSIN Research Div.

15 AUGUST 1963 9p (cy)

Director
George C. Marshall Space Flight Center
Huntsville, Alabama
Attention: M-P and C-CA

Gentlemen:

This is the fifteenth monthly progress report submitted under Contract Number NAS8-2696. Work conducted on the Static Vapor Pressure Control System, which was previously reported under this contract, is now being reported under Contract Number NAS8-5392.

Previous laboratory testing of the breadboard recirculation system used a combination of external heaters and convective air cooling in order to cool and control the temperature of the fuel cell module. Since air cooling would be impractical in a space vehicle application, much of the testing during the past month has been devoted to the development of a liquid cooling system, in order to acquire a clearer insight into the problems associated with its use.

Liquid Coolants

In selecting a liquid coolant for the revised recirculation system, the following four types of coolants which were readily available were considered:

(1) Distilled water
(2) Ethylene Glycol
(3) 50 - 50 Water-Glycol Mixture
(4) Coolanol "35"

These were evaluated on the basis of their cooling ability, dialectric strength, cost, and compatibility with other system materials.

In order to determine the possible current leakage between cells through the coolant, a group of tests were conducted using the coolants listed above. Two nickel plated fuel cell plates were bolted together with a 1/32" Butyl gasket separator and submerged in the liquid under test. This test set-up, together with the current leakage in milliamperes at various potential differences between plates, and various liquid temperatures, is shown on Figure 3. These tests indicated that Coolanol "35" was the best coolant in this respect. The water-glycol mixture appeared to be adequate also. The water-glycol mixture was selected for initial tests because of its low cost and its use in other space applications. A more complete evaluation will be possible after initial system tests have been completed.

Breadboard Recirculating System

The breadboard system has been reassembled incorporating the changes discussed in the last monthly report. The two major changes were the substitution of an oxygen purge system for the oxygen recirculation system and the extension of the liquid cooling system to include cooling of the fuel cell module. The first change reduced parasitic power by about 25% and system weight and volume by a similar amount. The revised schematic drawings of the reactant system and coolant system are shown in Figures 1 and 2 respectively.

During initial testing the system operated very well under a 30 ampere load for several hours. Water removal, module performance, and temperature control were all normal. After about one hour of operation, gas began bubbling through the expansion chamber of the cooling system. The bubbling increased until the system was shut down for further investigation.

A sample of the gas was collected and analyzed. It was found to be predominately hydrogen with some oxygen. Tests will be conducted on the water-glycol coolant mixture to determine if the gas is being formed by electrolysis. In the interim, the water-glycol will be replaced by Coolanol "35" and testing will be resumed.

Component Development

Previous tests on the metal static condenser-separator discussed in previous reports indicated an improvement in performance may be possible if heat were removed more rapidly from the face of the asbestos separator. To investigate this, a new plate was machined with cooling fins for improved heat transfer. The revised condenser-separator, illustrated in Figure 4, is scheduled to be tested in August.

Machining Magnesium Cell Plates

1. Chemical Machining

   A study of machining fuel cell plates by various chemical methods has been made by Williston Engraving Company, Milwaukee, together with Dow Chemical Laboratories. These studies indicated that chemical machining is not an economical method of machining fuel cell plates.

2. Die Casting

   Dow Chemical Company Laboratories have investigated the possibility of forming fuel cell plates by the die casting method. Consideration was given to the nickel plating problems associated with die cast material as outlined in a letter to us from Furniture City Plating Company. Dow Chemical Company has expressed their confidence in developing a magnesium allow which will produce satisfactory die cast fuel cell plates.

   Due to the high cost of dies, this method of forming plates does not become economical until a minimum of about 100 identical plates are required. This appears to be a promising method and investigations will be continued.

3. Electric Discharge Method

   The possibility of machining magnesium plates by the Electric Discharge Method (EDM) is also under investigation. Delivery of sample plates, machined by this process, has been promised for the week of August 5.

Future Work

1. Continue testing of revised breadboard system.

2. Complete testing of metal condenser-separator and mixing valve.

3. Continue plate machining investigations.

During the month of July approximately 656 man-hours were expended.

David P. Ghere

David P. Ghere, Project Leader

J. L. Platner

John L. Platner, Section Head

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SCHEMATIC OF FUEL CELL GAS SYSTEM (REV. A)

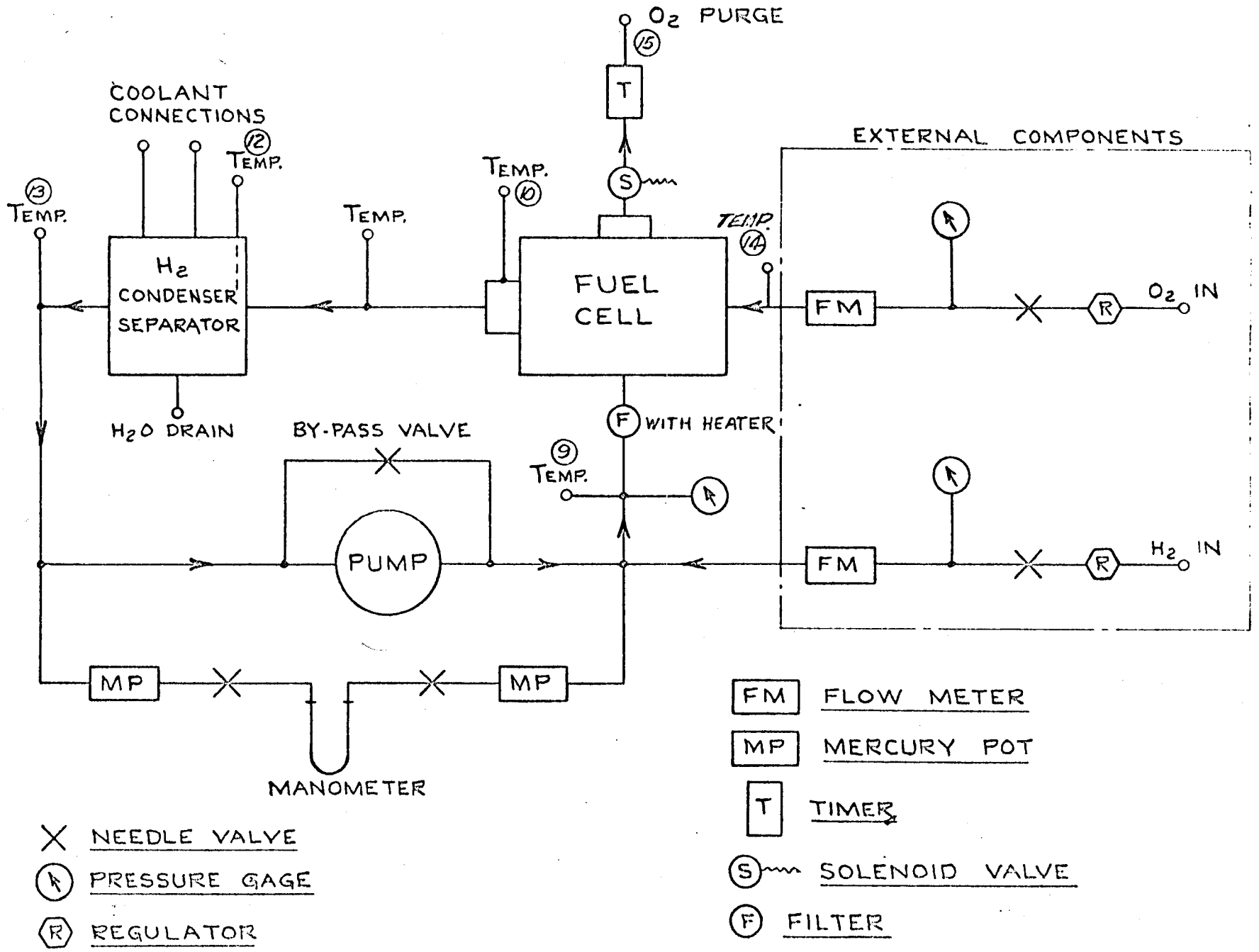
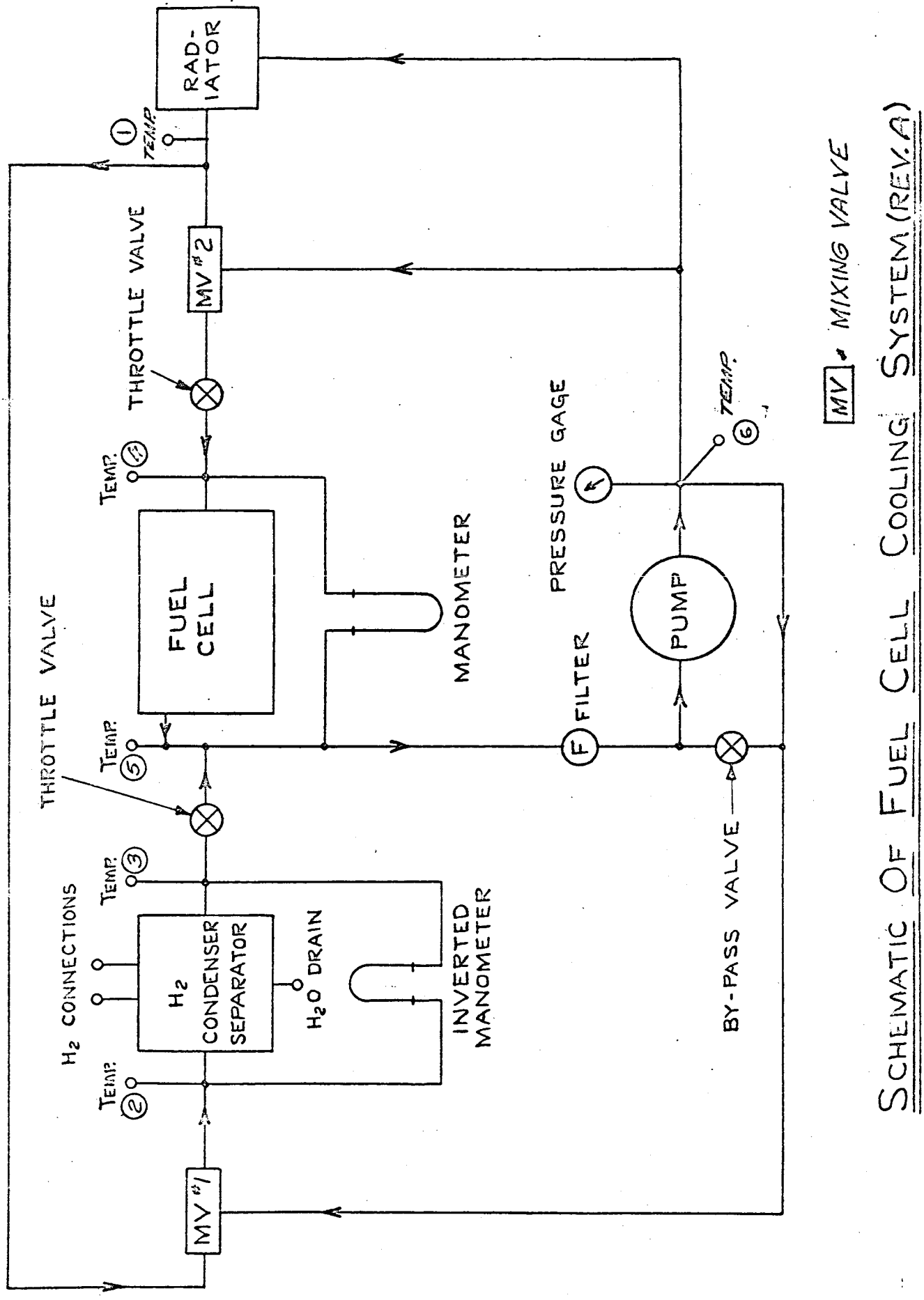


FIG. NO. 1

ALLIS-CHALMERS MFG. CO.

REV. #1 MADE 7-22-63
MADE 6-11-63

1-SK-63175-51



SCHEMATIC OF FUEL CELL COOLING SYSTEM (REV. A)

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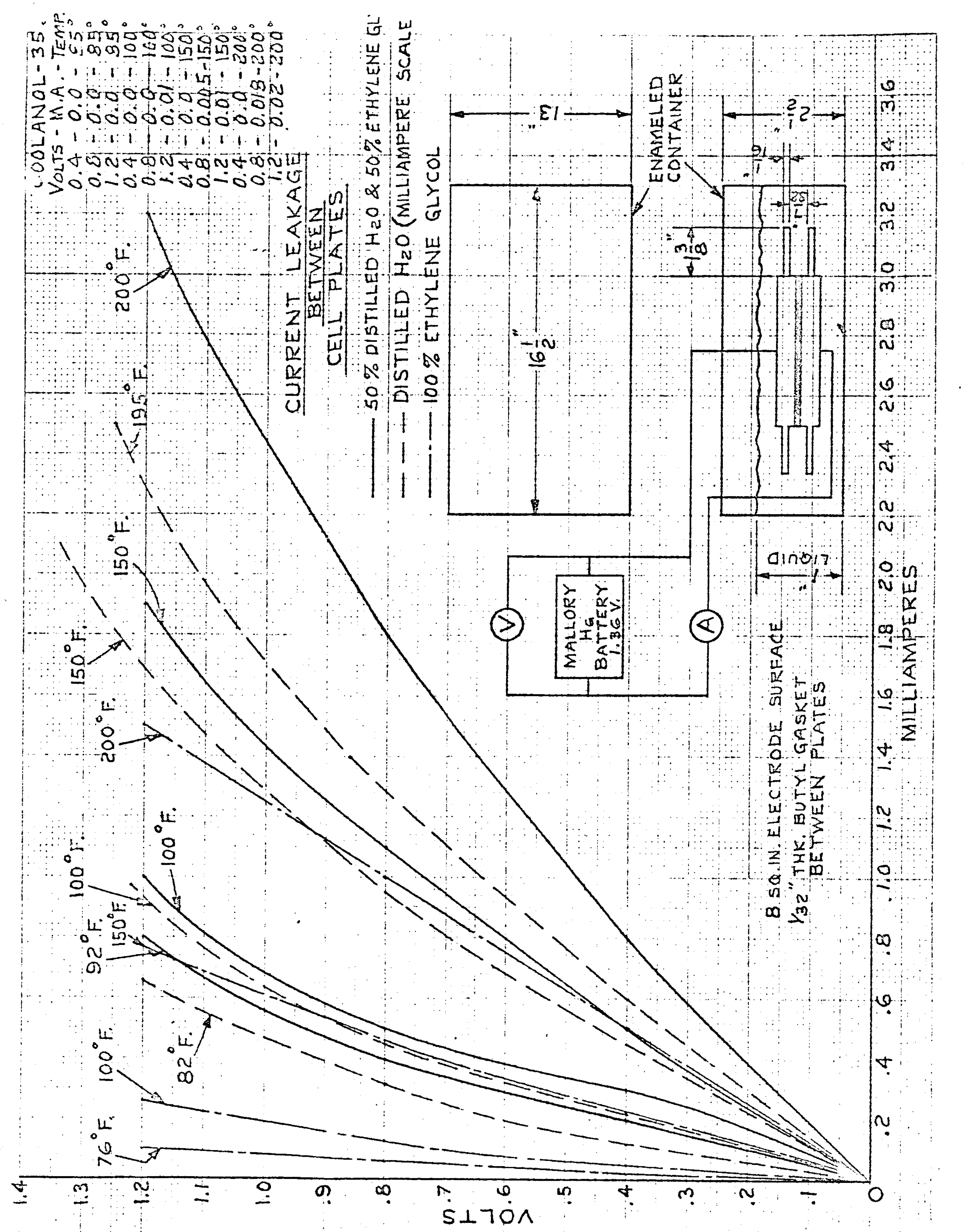
FIG. No. 2

REV. #2 W.P.B. 7-26-63
REV. #1 - W.P.B. 7-23-63
W.P.B. 6-7-63

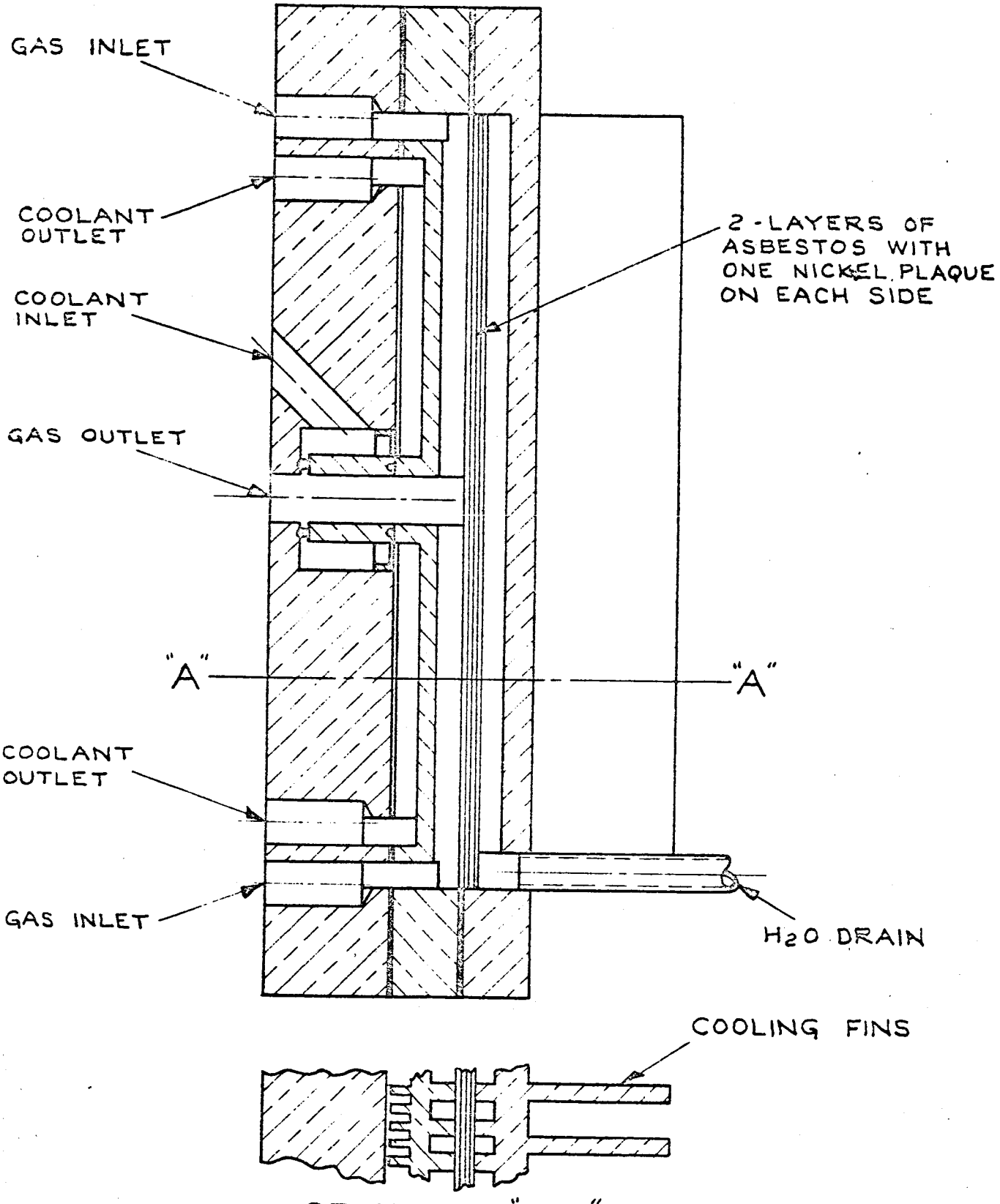
1-SK-C3175-50


COOLANOL-35.
VOLTS - M.A. - TEMP.
0.4 - 0.0 - 85°
0.8 - 0.0 - 85°
1.2 - 0.0 - 85°
0.4 - 0.0 - 100°
0.8 - 0.0 - 100°
1.2 - 0.01 - 100°
0.4 - 0.0 - 150°
0.8 - 0.005 - 150°
1.2 - 0.01 - 150°
0.4 - 0.0 - 200°
0.8 - 0.018 - 200°
1.2 - 0.02 - 200°
CURRENT LEAKAGE
BETWEEN
CELL PLATES
50% DISTILLED H2O & 50% ETHYLENE GL
DISTILLED H2O (MILLIAMPERE SCALE
100% ETHYLENE GLYCOL
200° F.
195° F.
150° F.
150° F.
200° F.
100° F.
100° F.
92° F.
150° F.
100° F.
82° F.
76° F.
16 1/2"
3"
ENAMELED CONTAINER
1 3/8"
1/2"
1/8"
1/16"
2"
LIQUID
MALLORY HG BATTERY 1.36 V.
V
A
8 SQ. IN. ELECTRODE SURFACE
1/32" THK. BUTYL GASKET BETWEEN PLATES
VOLTS
MILLIAMPERES
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6

ALLIS-CHALMERS MFG. CO. FIG. No. 3

H.P.B. 7-18-6
1-SK-13199-2

CONDENSER - SEPARATOR ASSEMBLY (REV. A)



SECTION ~ "A-A"

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FIG. Nº 4

1-SK-63210-1
H.P.B. 7-5-63